result from Gordan's researches, which are indubitably correct. This supposed consequence must have arisen from a misapprehension, on the part of M. de Bruno, of the nature of Professor Cayley's rectification of the error of reasoning contained in his second memoir on Quantics, which had led to results discordant with Gordan's. Thus error breeds error, unless and until the pernicious brood is stamped out for good and all under the iron heel of rigid demonstration. In the early part of this year Mr. Halsted, a fellow of John's Hopkins University, called my attention to this passage in M. de Bruno's book; and all I could say in reply was that 'the extrinsic evidence in support of the independence of the equations which had been impugned rendered it in my mind as certain as any fact in nature could be, but that to reduce it to an exact demonstration transcended, I thought, the powers of the human understanding.'"

In 1883 Sylvester was made Savilian professor of geometry at Oxford, the first Cambridge man so honored since the appointment of Wallis in 1649.

To greet the new environment, he created a new subject for his researches—Reciprocants, which has inspired, among others, J. Hammond, of Oxford; McMahon, of Woolwich; A. R. Forsyth, of Cambridge; Leudesdorf, Elliott and Halphen.

Sylvester never solved exercise problems such as are proposed in the *Educational Times*, though he made them all his life long down to his latest years. For example, *unsolved* problems by him will be found even in Vol. LXII. and Vol. LXIII. of the *Educational Times* reprints (1895). If at the time of meeting his own problem he met also a neat solution he would communicate them together, but he never solved any. In the meagre notices that have been given of Sylvester the strangest errors abound. Thus C. S. Pierce, in the *Post*, March 16th, speaks of his accepting, 'with much diffidence,' a word whose meaning he never knew; and gives 1862 as the date of his retirement from Woolwich, which is eight years wrong, as this forced retirement was July 31, 1870, after his 55th birthday. Cajori, in his inadequate account (History of Mathematics, p. 326), puts the studying of law before the professorship at University College and the professorship at the University of Virginia, both of which it followed. Effect must follow cause. And strange, that of the few things he ascribes to Sylvester, he should have hit upon something not his, "the discovery of the partial differential equations satisfied by the invariants and covariants of binary quantics." But Sylvester has explicitly said in Section VI. of his 'Calculus of Forms:' "I alluded to the partial differential equations by which every invariant may be defined. M. Aronhold, as I collect from private information, was the first to think of the application of this method to the subject; but it was Mr. Cayley who communicated to me the equations which define the invariants of functions of two variables."

Surely he needs nothing but his very own, this marvellous man who gave so lavishly to every one devoted to mathematics, or, indeed, to the highest advance of human thought in any form.

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*THE GREAT FAULT AND ACCOMPANYING SANDSTONE DIKES OF UTE PASS, COLORADO.**

THREE year years ago Whitman Cross first directed the attention of geologists to the fact that dike-like masses of sandstone occur in the granite of the Pike's Peak massif, forming a belt about one mile wide extending north-northwest from the vicinity of Green Mountain Falls, in Ute Pass,

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along the southwest side of the narrow Manitou Park, basin of sedimentary rocks (Silurian and Carboniferous). Among the more important characteristics of the dikes noted by Cross are the following: 1. The dikes have a general trend parallel to the belt in which they occur; are approximately vertical and often appear as a complex of nearly parallel fissures with many branches and connecting arms; and vary in width from mere films to two or three hundred yards, the largest being a mile or more in length, and forming rugged ridges with narrow crests which contrast markedly with the gentle sloping hills of granite about them. In short, "In all formal relationships to the enclosing rocks these bodies are as typical dikes as any of igneous origin." 2. The rock of the dikes is a fine and even-grained aggregate of sand grains varying in degree of induration from a normal sandstone to a dense hard quartzite, but throughout of a remarkably massive and uniform character.

During the past summer of 1896 I was able to devote several weeks to the investigation of the sandstone dikes and the great displacement to which I have found them to be genetically related. To the dikes described by Cross I gave only sufficient attention to become familiar with their characteristics, and then endeavored to trace the series southeastward through Ute Pass to Manitou and beyond.

The sedimentary formations of the Manitou area embrace, from below upward, as described by Hayden, Cross and others: 1. A basal sandstone which is usually 40 to 50 feet thick, white or gray for the lower 10 to 15 feet and dull red or brown above, only rarely of arkose character, but frequently more or less glauconitic. 2. This sandstone, which may be referred provisionally to the Potsdam, becomes calcareous upward, passing into red, cherty limestones, and these into a massive gray limestone having a thickness of several hundred feet. The limestones are throughout more or less magnesian and contain recognizable traces of a Lower Silurian (Ordovician) fauna. 3. This great Manitou limestone series is overlain without apparent unconformity by the Fountain (Carboniferous) beds 1,000 to possibly 1,500 feet in thickness—a remarkable complex of red and white arkose sandstone, grits and conglomerates. 4. The red sandstone series (Triassic), a thousand feet or more in thickness. 5. The white, variegated and gypsiferous Jurassic strata. 6. The Cretaceous series, beginning with the massive and conspicuous Dakota sandstone.

Each of these formations is cut off on the south by the great fault which skirts the northeastern base of the Pike's Peak massif. This profound displacement, which must be regarded as a dominant factor in the geological structure of the region, and to which we undoubtedly owe, in the main, the Manitou embayment of sedimentary rocks and the exceptional elevation of the Pike's Peak massif as compared with the Front Range to the north of Ute Pass, gained early recognition and is clearly indicated on Hayden's maps of the Manitou area. It is altogether probable that the fault by which Cross has bounded the Manitou Park sediments (Potsdam, Manitou limestone, and Fountain series) on the southwest is a direct continuation of that which, cutting across the strike of the beds, is so much more conspicuous in the Manitou area. This great displacement, which divides very obliquely the entire Front Range and the beds lying upon either flank of the range and sloping away from its crest, may therefore be appropriately designated the Ute fault. Erosion has cut deeply enough over the top of the arch to remove the sedimentary rocks from the down-throw as well as the up-throw side of the fault. The Ute fault cuts every formation of the region from the fundamental

granite and the Potsdam to the Laramie, and in its maximum throw must exceed the aggregate thickness of the Paleozoic and Mesozoic terranes; and its completion, at least, must date from relatively late geological times.

I have succeeded in tracing the sandstone dikes from the vicinity of the Iron Spring, in Manitou, northwest along the great fault two miles, or a little farther than the sedimentary rocks extend, and southeastward from Manitou, along the base of the mountains, and closely following the Ute fault, to Cheyenne Cañon and beyond, a distance of six miles. The dikes of this series vary in width up to 500 or 600 feet. A large dike usually follows the main line of displacement, separating the sedimentary rocks and granite, with one to several other dikes closely parallel with it in the granite. Almost without exception the dikes exhibit a strong southwesterly hade, making angles of 5 to 75 degrees with the vertical, and slickensided shear planes at corresponding angles are very common. Although the rock is prevailingly a fine and even-grained gray and reddish-brown sandstone, identical with that described by Cross, much of it is decidedly coarser, and at several points it is distinctly conglomeratic. In several dikes, also, the sandstone is more or less distinctly stratified.

Mr. Cross has briefly discussed the origin of the sandstone dikes, without arriving at a definite conclusion. He recognizes that these sandstone dikes are radically distinct in character and origin from those described by Diller in California, and asserts that the known facts do not indicate the source of the sand; that the facts do show that the fissures of this dike complex were filled by fine quicksand injected from a source containing a large amount of homogeneous material; that such a system of fissures, large and small, with their many intersections, could not remain open to be filled by any slow process; that the uniformity and purity of the material filling fissures varying from mere films on cleavage planes of orthoclase grains in the granite to dikes several hundred yards in width could not have resulted from infiltration; and, finally, that none of the sedimentary formations of the region can be regarded as probable sources of the material.

My study enables me to accept all of these generalizations, except the last one. The most important of the facts which the true theory of the dikes must explain are: first, their very evident close relationship to an important zone of displacement; second, the homogeneity of the materials and the general absence of stratification in the dikes; third, the great maximum and average widths of the dikes.

The relations of the dikes to the great Ute fault are indisputable. Not only is the fault at most points closely accompanied by one or more dikes; but nowhere have I been able to find any trace of the dikes more than a few hundred feet (500 to 1,000 feet) distant from the principle line of displacement. That these fissures, unlike the relatively narrow ones described by Diller in California, have not been filled from below becomes perfectly obvious when we reflect that the inclosing rock formation is a deep-seated plutonic. The homogeneity and purity of the sandstone, and especially the absence of feldspathic or argillaceous material, make it impossible to regard the dike rock as a fault breccia or as due in any way to the comminution of the wall rock. Ruling out this theory and infiltration, we are forced to the conclusion that the fissures have been filled from above. But of this theory two principal forms naturally suggest themselves. First, the fissures antedate the deposition of the sand, existing as cracks in the sea-botton which were filled by the slow process of sedimenta-

tion. Second, the cracks post-date the deposition of the sand, but antedate its lithification to form a firm sandstone and the unconsolidated sand subsided and flowed down into and filled the fissures.

By this process of elimination we are forced to the consideration of the view that the fissures were formed after the granite had been covered by the sedimentary deposits and before their complete consolidation, the unconsolidated portions naturally contributing to the filling of the fissures and the formation of the dikes. There are two questions especially which the acceptance of this explanation would require to be answered in the affirmative. First, are there, among the sediments of the Manitou and Manitou Park basins, any that, aside from structural features like stratification, which would, of course, be obliterated during the filling of the fissures, present a reasonably close agreement in character (composition and texture) with the sandstone of the dikes? Second, may we reasonably assume that these sediments were, in part at least, unconsolidated or imperfectly consolidated at the time when the fissures were formed? The only sandstone formations that need be considered in this connection are the Potsdam, Carbon iferous, Triassic and Dakota. Of these four sandstone horizons the last three bear no special resemblance to the material of the sandstone dikes. On the other hand, I became convinced before the field work was finished that the Potsdam beds and the dikes are lithologically identical. The dike rock is absolutely indifferent to the changes in the character of the neighboring formations, showing no appreciable variation, as in succession, from Manitou southeast to Cheyenne Cañon, the Potsdam, Silurian, Carboniferous, Triassic and Dakota beds abut against or border the great fault.

The close association of the dikes, throughout the entire belt, with the great displacement, and their unvarying lithological similarity to the Potsdam sandstone, have suggested to me that the dikes probably date from the formation of the Ute fault; that the fault probably dates from the time when the Potsdam beds, which are still, at the base, in part of a more or less friable character, were imperfectly consolidated and covered the entire region; that the fault, as is likely to be the case with a great displacement, was not simple, but that a moderate breadth of the granite and overlying formations was traversed by a series of parallel fissures; and that the dikes resulted from the sinking of the Potsdam sandstone and sand into the fault fissures. Such local subsidences of the friable sandstone would naturally be attended by a more or less complete obliteration of the bedding.

No single feature of the dikes is more significant than the great breadth of individual examples. Although presenting, apparently, an insuperable obstacle to all the other suggested explanations of the sandstone dikes, it offers no difficulty whatever to the theory proposed here, for we have only to make the extremely probable supposition that sheets of granite of varying width and bordered by complementary faults have settled down relatively to the bordering masses, bearing with them their loads of Potsdam sediment.

W. O. CROSBY.

EXHIBITION IN SCIENCE BY THE NEW YORK ACADEMY OF SCIENCES.

THE Fourth Annual Exhibition of Recent Progress in Science, given by the New York Academy of Sciences, was held at the American Museum of Natural History on April 5th and 6th, and was in every way the most successful in the history of the Society. The exhibit occupied the floor space of the main hall and bird gallery, and was attended by an estimated number of more